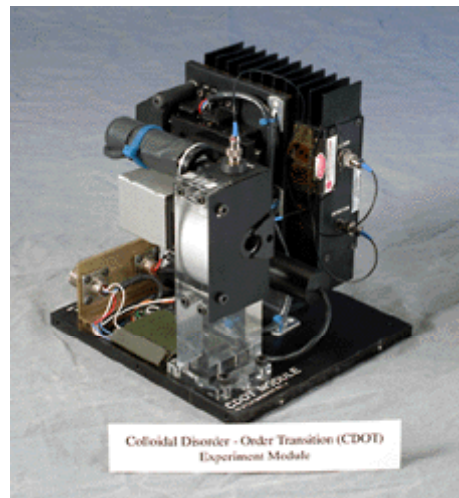


Colloidal Disorder-Order Transition Experiment Probes Particle Interactions in Microgravity

Everything in the universe is made up of the same basic building blocks--atoms. All physical properties of matter such as weight, hardness, and color are determined by the kind of atoms present and the way they interact with each other. The Colloidal Disorder-Order Transition (CDOT) shuttle flight experiment tested fundamental theories that model atomic interactions. The experiment was part of the Second United States Microgravity Laboratory (USML-2) aboard the Space Shuttle Columbia, which flew from October 20 to November 5, 1995.

The CDOT experiment used colloidal suspensions of microscopic plastic spheres as a model of atomic interactions. A colloidal suspension, or colloid, is a system of fine particles suspended in a fluid. Paint, ink, and milk are examples of colloids found in everyday life. When the particles in a colloidal suspension are uniformly sized spheres that cannot penetrate each other (hard spheres), this system shares a very fundamental characteristic with atomic systems--both undergo a transition from a disordered liquid state to an ordered solid state under the proper conditions. The freezing of water to form ice crystals as temperature is lowered is a familiar example. With hard-sphere systems, the liquid-to-solid transition occurs as the average spacing between the spheres is varied. The gravitational effects of sedimentation and convection limit definitive colloidal experiments on Earth. By conducting hard-sphere experiments in the microgravity environment of space, we hope to gain a better understanding of the liquid-to-solid transition and, thereby, the structures and properties of solids.



Colloidal Disorder-Order Transition (CDOT) flight experiment module.

During orbit, astronauts gathered data on 15 hard-sphere samples, including 35-mm and digital photographs, video images, and digital correlation data. The CDOT hardware operated in the Spacelab Glovebox Facility. This first set of hard-sphere data from

microgravity yielded several interesting and valuable results. A number of the photographs revealed the first physical evidence of dendritic growth in hard-sphere crystals. Dendrites, snowflakelike structures that are a common feature of atomic materials, are not observed in hard-sphere systems on Earth because of the effects of gravity. Laser-light-scattering video images indicate that the structure of the crystals formed in space were also different from the structure of crystals formed on Earth. On Earth, colloidal crystals are a mixture of face centered cubic and random hexagonal close-packed structures. In microgravity, it appears that crystals form only random hexagonal close-packed structures. Lastly, a high volume fraction sample that did not crystallize on Earth readily crystallized in microgravity. This suggests that the glassy state observed on Earth may be an artifact of gravity, not a thermodynamic state.

The CDOT experiment was conceived by Professors Paul M. Chaikin and William B. Russel of Princeton University and William V. Meyer of the Ohio Aerospace Institute. The experiment hardware was designed by Aerospace Design & Fabrication, Inc. (ADF) and was built and tested by the NASA Lewis Research Center under the direction of Richard B. Rogers of NASA, Dr. Jixiang Zhu of Princeton University, and the experiment originators. The CDOT instrument employed several laser-light-scattering techniques using state-of-the-art avalanche photodiodes and digital correlation hardware. Both of these components represent advances in commercially available products that were driven by NASA requirements for microgravity research.

CDOT is the first of a series of planned space shuttle and space station colloids experiments. The knowledge gained from these experiments will allow scientists to better understand basic atomic interactions and may eventually help to reduce the trial and error involved in developing new and better materials. Industries dealing with semiconductors, electro-optics, ceramics, and composites are just a few that may benefit from this knowledge.